

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 38

TROUBLESHOOTING EXPERIMENTS II



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Experiment Lesson 38

INTRODUCTION

The audio-amplifier section includes the volume control, first audio amplifier, power-output amplifier, output transformer and speaker. The function of this section of the receiver is to amplify the audio signal until it has sufficient power to drive the loudspeaker. In order to do this, the voltage amplifier increases the relatively weak output of the detector to give the audio signal sufficient voltage swing to drive the power output tube, which in turn develops sufficient power to drive the loudspeaker.

The defects that may occur in this section of the receiver are as follows:

- a. No output
- b. Weak output
- c. Distorted output
- d. Hum in the output
- e. Motorboating
- f. Oscillation

In this lesson, you will learn about various checks that can be made and how a normally operating stage will respond to these checks. You will then introduce defects and observe how these defects change these normal indications.

EXPERIMENT 38-1

To observe normal indications for the power-output stage.

Procedure.

Step 1. With power disconnected from the receiver, make the resistance measurements indicated in Table A using the appropriate ohmmeter scale. Record the results in Table A.

Step 2. Apply power to the receiver. Measure the d-c voltages indicated in Table B and record the results in the table.

Step 3. Tune in a broadcast signal; music is best for this test. With the volume control set to give normal volume, measure the average output meter readings at the points listed in Table C. Use the appro-

TABLE A

Measurement	Resistance (ohms)
Plate of output tube to chassis PIN 3 ∞	
Screen grid of output tube to chassis 4 ∞	
Across output transformer primary 350	
Control grid of output tube to chassis 5 ∞	
Cathode of output tube to chassis 4 70	

TABLE B	
Measurement	Voltage (volts d.c.)
Plate of output tube 3	
Screen grid of output tube 4	
Across output transformer primary	
Control grid of output tube 5	
Cathode of output tube 8	

appropriate a-c scale and the output meter connection. Record your results in Table C.

Step 4. Plug in the signal generator and allow it to warm up. Connect the signal generator output cable to the AF OUTPUT jack. Apply the signal generator to the plate of the output stage. With the output meter connected to the control grid of the power amplifier, adjust the AF OUT/INT MOD control to give some convenient reading on the meter, for example two volts. Then transfer the meter leads to the plate

TABLE C	
Measurement	Voltage (volts a.c.)
Control grid of the 5 output tube	
Plate of the output 3 tube	
Cathode of the 8 output tube	
Screen grid of the 4 output tube	

of the power-amplifier stage and note the reading. Divide the second reading by the first to obtain the approximate voltage gain of the stage.

Discussion. A complete schematic of your receiver appears in Fig. 38-1. A schematic diagram of the complete audio-amplifier section of your receiver appears in Fig. 38-2. The proper resistance readings that should have been obtained at the various points called for in Table A can be readily predicted from the circuit component values given in the schematic diagram. The voltage readings that should be obtained for this receiver are given on this diagram. Table D gives the range of d-c voltages that are likely to be encountered for various points in a typical stage of this type:

Note that the plate voltage should always be slightly (10 or 15 volts) lower than the B+ voltage. This is due to the IR voltage drop caused by the plate current flowing through the d-c resistance of the output-transformer primary winding. If this voltage is exactly the same, it is a very likely indication that plate current is not flowing. Possible causes for this are a defective output tube or an open cathode resistor.

The voltage at the cathode is the bias voltage for the tube. It is also a valuable

TABLE D	
Measurement	Voltage (volts d.c.)
Plate of output tube 3	225 to 260
Screen grid of output 4 tube	235 to 270
Control grid of output 5 tube	0
Cathode of output 8 tube	12 to 18

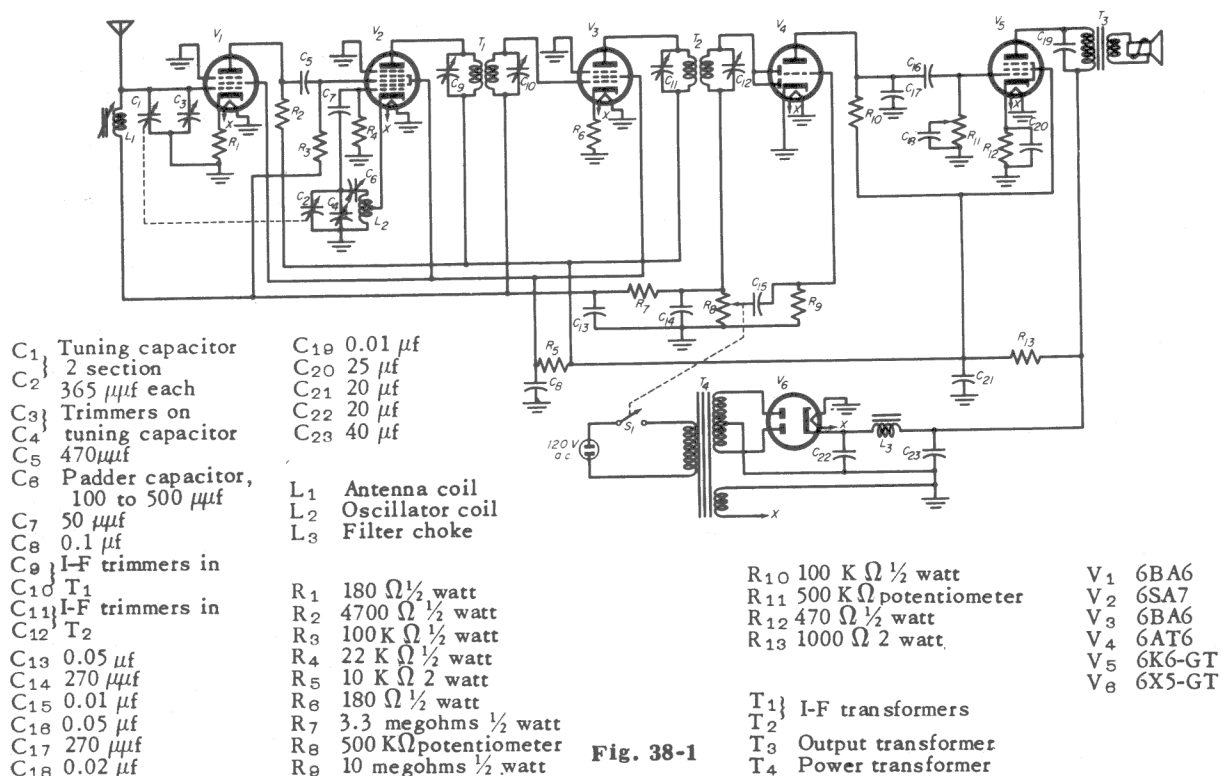


Fig. 38-1

troubleshooting indication, because it indicates the amount of current flowing in the tube and can be used as an indication of whether or not the correct amount of current is being drawn by the tube.

With the signal-generator input directly to the grid of the power-amplifier tube and the audio-output control adjusted to give two volts, about 32 volts is obtained at the plate of the tube. Thus the voltage gain of the power amplifier is about 16. This test is a valuable troubleshooting indication when the cause of weak output is being investigated.

With the volume control adjusted to give normal volume, an average of about 2 volts a.c. is shown by a meter connected to the grid of the output stage, and an average of about 35 volts a.c. is obtained at the plate of this tube.

No signal voltage should be measured at the cathode or screen grid of the output stage, since they are bypassed. On the other hand, this measurement gives a check as to whether or not these bypass capacitors are functioning properly.

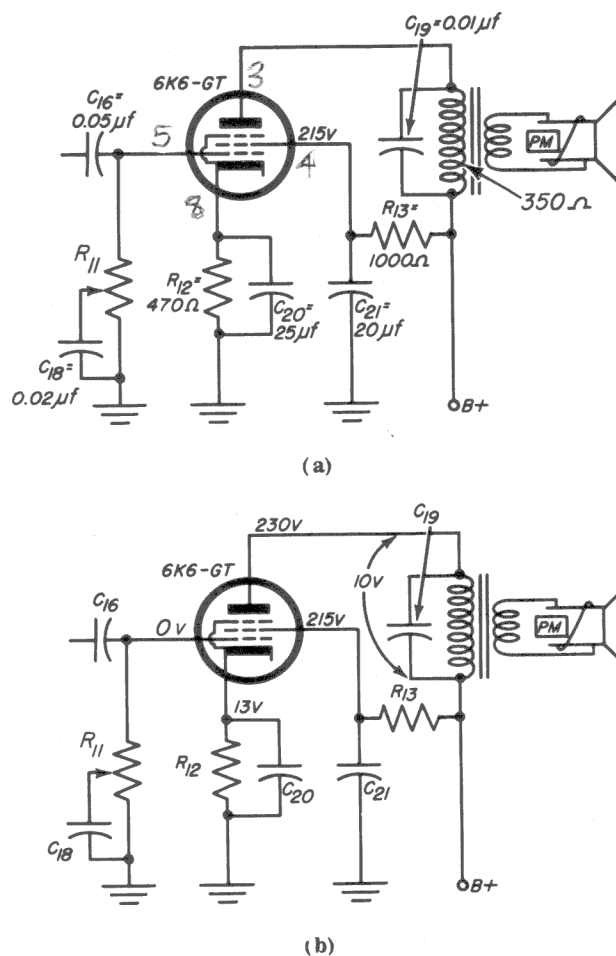


Fig. 38-2

EXPERIMENT 38-2

To make dynamic checks for the power-output stage

Procedure.

Step 1. Disconnect power from the receiver. Set up the ohmmeter to the $R \times 1$ position. Touch the ohmmeter leads across the voice-coil terminals several times while listening to the loudspeaker. What is heard? What does this test tell about the condition of the voice-coil of the loudspeaker? Why is this test a better one than measuring the continuity of the voice coil?

Step 2. Touch the ohmmeter leads across the blue and red leads of the output transformer several times while listening to the loudspeaker.

What is heard? What does this test tell about the condition of the output transformer?

Step 3. Remove the r-f amplifier tube to simulate a dead receiver. Connect power to the receiver and allow it to warm up. Remove the power amplifier tube (be careful — it may be hot) and put it in and pull it out of the socket several times while listening to the loudspeaker.

What does this test tell about the condition of the output transformer and the loudspeaker? If you were troubleshooting a dead receiver, which of the above tests (Steps 1, 2, or 3) would you make first?

Step 4. Inject a 6-volt 60-cycle a-c signal into the control grid of the power-amplifier tube. Do this by connecting a capacitor ($0.01 \mu\text{f}$ or larger) between the grid of the power-amplifier tube and any convenient source of filament voltage on the chassis. What is heard in the loudspeaker? What does this test tell about the condition of the output stage? A convenient device for this and other tests may be made from an alligator clip, a terminal strip, a $0.05 \mu\text{f}$ 600-volt paper capacitor, a test prod, and some test lead wire, as shown in Fig. 38-3.

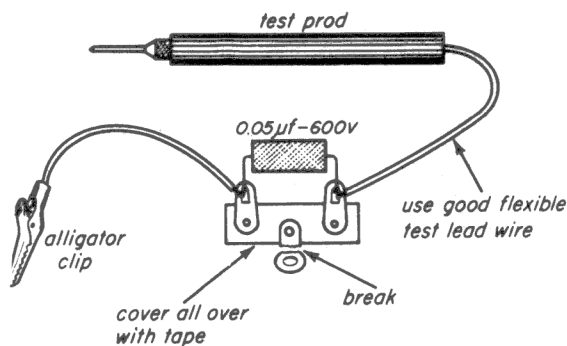


Fig. 38-3

Step 5. Put your finger on the grid of the output tube. Is a hum heard in the loudspeaker? Why?

Step 6. Remove the first audio tube (be careful — it may be hot) and put it in and pull it out of the socket several times while listening to the loudspeaker. What is heard? What does this test tell about the condition of the power-amplifier stage? What does this test tell about the condition of the first audio stage?

Step 7. Inject a 400-cycle audio signal from the signal generator to the plate of the output tube. Set the audio output control on the signal generator so that the audio signal is barely heard in the loudspeaker. Move the signal-generator cable to the grid of the output tube and note the increase in volume. Also, move the signal generator cable to the other side of the coupling capacitor (plate of the first audio tube) and note the change in volume.

Caution. Your signal generator can be connected to points in the circuit at $B+$ potential because of the blocking capacitors in the circuit. But other signal generators that you may use might not have such blocking capacitors. In general, it is safe practice to always employ a blocking capacitor in series with the signal generator cable. A capacitor of $0.01 \mu\text{f}$ or larger is usually satisfactory for audio signals.

What does this test show about the condition of the power amplifier?

Step 8. When a signal generator is not available, you can make a rough check of whether or not the output tube is amplifying

by using a $0.05\ \mu\text{f}$ capacitor to inject a 60-cycle voltage into the circuit. Connect the capacitor from pin 7 of the output tube to pin 3 of this tube. Listen closely to the loudspeaker for the hum produced. Then move the capacitor from the plate and connect it to the control grid and note the increase in volume. The passage of signal through the coupling capacitor can also be checked in this way, by moving the blocking capacitor from the grid and connecting it to the input side of the coupling capacitor.

Discussion. The dynamic checks described in this experiment may be used for quick isolation of the trouble when servicing completely dead receivers. When the ohmmeter leads are connected across the voice-coil terminals of a good loudspeaker, a plop is heard both when the circuit is made and when the circuit is broken. This test can be made without disconnecting the voice coil from the secondary of the output transformer and also shows that the voice coil, in addition to having continuity, is free to move.

Similar plops in the loudspeaker are heard at the make and break when the ohmmeter leads are connected across the output transformer primary. This test shows that there is no break in the output transformer primary or secondary winding. Power must not be connected to the receiver when this test is made.

Removing and inserting the output tube is called the *click* test. Although this test is very conveniently performed from the top of the chassis it should not be used too often; there is danger of high voltage surges developing across the output transformer. The test establishes that everything from the *plate* of the output tube to the voice coil of the loudspeaker is functioning properly. Note that it does *not* test the output tube itself.

To test whether the output tube itself is passing signal, an external signal can be applied to the grid of the output tube by any one of the methods given above. Pulling out and reinserting the first audio tube serves as a check on the circuit from the plate of the first audio tube back to the loudspeaker.

Putting the finger on the output tube grid usually does not produce audible hum in the loudspeaker because the output stage does not have enough gain.

Injecting a signal first on the plate, and then on the control grid, gives a quick check as to whether the tube is amplifying. If desired, measurements of the amount of gain may be made as previously described.

EXPERIMENT 38-3

To troubleshoot the power-output stage.

Procedure.

Step 1. To stimulate a defective output tube, remove the tube from its socket. What dynamic checks have you learned from the previous experiments in this lesson that will point out a defective output tube? Try some of them.

Step 2. Measure the cathode voltage. How does this compare with the normal indication?

Step 3. Measure the voltage across the output transformer primary. How does this compare with the normal indication?

Let us assume that by using one or more of the checks outlined above, you have already isolated the trouble as being somewhere in the output stage. Now let us see how the defective component can be isolated.

Step 4. To simulate an open primary winding in the output transformer, disconnect the blue lead from the output transformer at pin 3 of the power amplifier tube. Replace the tube in its socket. Measure and record the voltages called for in Table E.

How do these voltages differ from the normal voltages for this stage?

Step 5. Reconnect the blue lead from the output transformer to pin 3 of the power amplifier tube.

TABLE E	
Measurement	Voltage (volts d.c.)
Plate voltage	
Screen grid voltage	
Cathode voltage	

Step 6. To simulate an open cathode resistor, disconnect the cathode resistor of the power amplifier tube at pin 8 of the tube socket.

Caution: To prevent possible damage to the cathode bypass capacitor, it must also be disconnected.

Measure the d-c voltages called for in Table F.

TABLE F	
Measurement	Voltage (volts d.c.)
Plate voltage	
Screen grid voltage	
Cathode voltage	
Voltage across output transformer primary	

Which voltages differ drastically from the normal voltage?

Step 7. Reconnect the cathode resistor and bypass capacitors.

Discussion.

An output tube with no emission, as simulated by removing the output tube, results in two telltale indications. First, there is no voltage drop across the cathode resistor and no voltage drop across the output transformer primary. The lack of voltage drop at these two points indicates positively that there is no current flow through the

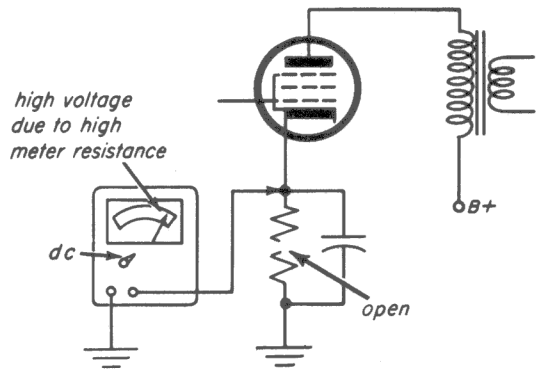


Fig. 38-4

tube. When plate and screen-grid voltages are present, this can be due only to a defective tube.

An open primary winding in the output transformer results in no plate voltage and this defect can be readily located by resistance checks of the output transformer. An open cathode resistor gives a result that may be unexpected — the meter indicates almost the entire B+ voltage. The reason for this can be seen by referring to Fig. 38-4. The break in the circuit is bridged by the electrolytic leakage resistance and by the meter when it is inserted. The voltage shown by the meter is determined simply by voltage-divider principles. The parallel resistance of the meter and electrolytic leakage is usually very much higher than the d-c resistance of all other circuit elements in this series circuit. Therefore, almost the entire B+ voltage is dropped across the meter.

Since the voltage across the electrolytic capacitor may rise very high when the cathode resistor opens, there is a possibility that the electrolytic may be damaged. When replacing an open cathode resistor, the cathode bypass capacitor should always be checked.

EXPERIMENT 38-4

To perform additional troubleshooting of the power output amplifier.

Procedure.

Step 1. At the cathode (pin 8) of the output tube, disconnect the lead from the

electrolytic capacitor in order to simulate an open cathode bypass capacitor.

Step 2. Operate the receiver and note how the volume compares with normal operation.

Step 3. Set up the meter as an output meter and measure the voltage at the cathode. How does this compare with the normal voltage indication at this point?

Step 4. Replace the lead from the electrolytic capacitor to the cathode of the output tube.

Step 5. Make a mental note of the position of the volume control when normal volume is obtained from the loudspeaker.

Step 6. Turn off the receiver, and temporarily solder a 470 k-ohm resistor across the coupling capacitor to the output tube. This is to simulate a leaky coupling capacitor. This value of resistance is chosen for convenience only and does not represent the most typical leakage resistance.

Step 7. Return the volume control to the position that you recall as being its normal setting. How does the output volume now compare to the normal volume previously obtained? What happens to the quality of the sound as the volume control is advanced to obtain sufficient volume? Does the distortion get better or worse as the volume control setting is increased?

Step 8. Measure the d-c voltage between grid (pin 5) of the output tube and chassis. Is it positive or negative? How does it compare to the normal voltage that should be obtained at this point?

Step 9. Measure the d-c voltage between cathode (pin 8) and chassis. Is this voltage greater than normal? Why? Would you expect the actual bias on the tube between grid and cathode to be more or less than normal?

Step 10. Measure the voltage between pin 5 and pin 8 of the output tube (negative

meter lead to pin 5). What is the actual bias on the tube?

Step 11. Repeat steps 5 through 10 with a 100 k-ohm and a 47 k-ohm resistor. Are the results similar?

Step 12. Disconnect one side of the leakage resistor connected across the coupling capacitor.

Step 13. Remove the first audio (6AT6) tube. Connect the meter to measure the d-c voltage drop across the 6AT6 plate-load resistor (negative lead to the plate). Carefully move the range switch to the lowest range. Is any voltage indicated on the meter? Why?

Step 14. Set the meter back to a high range. Reconnect the leakage resistor, and repeat Step 13. Now is any voltage measured across the 6AT6 plate load resistor? Why?

Step 15. An alternate test for a leaky coupling capacitor is to disconnect the capacitor at the grid side, leaving it connected to the B+ side. Connect the voltmeter between the free end of the capacitor and chassis. Is any d-c voltage indicated?

Step 16. Remove the leakage resistor across the capacitor and repeat Step 15. Is any d-c voltage measured now?

Step 17. Reconnect the coupling capacitor to the grid of the output tube.

Step 18. Connect a short jumper between pins 8 and 1 of the output tube to simulate a shorted cathode bypass capacitor.

Step 19. Measure the d-c voltage between cathode and ground. How does this voltage compare with the normal bias voltage on this tube?

Step 20. Operate the receiver for a brief period of time, tuning in both voice and music programs and listen carefully for the presence of distortion. Listen for the distortion at both low and high volume settings.

Discussion. An open cathode-bypass capacitor causes a reduction in output volume due to degenerative feedback across the unbypassed cathode resistor. The defect can be located by noting that a signal voltage appears across the unbypassed resistor.

A defect that often occurs in the audio-amplifier section of a receiver is a leaky or shorted coupling capacitor. The leakage causes a reduction in output volume and produces distortion, which becomes very bad as the output volume is increased. Since a shorted coupling capacitor puts a positive voltage on the grid of the tube and reduces the bias to zero, it may cause damage to the output tube. This tube should always be checked when a shorted coupling capacitor is being replaced. There are several voltage readings which can be used to locate this defect.

As a result of the leakage, a positive voltage with respect to chassis is present at the grid of the tube. This causes increased current flow through the tube and a greater voltage drop across the cathode bias resistor. However, this does not result in a more negative bias for the tube, since the actual voltage between grid and cathode has been reduced to zero volts. When you suspect leakage in a coupling capacitor, you can check the capacitor in a number of ways.

One of the methods for locating a shorted coupling capacitor outlined in this experiment is based on the fact that there should be no current flow through the plate load resistor of a tube when that tube is removed, as shown in Fig. 38-5. However, if there is a short in the coupling capacitor, current will flow through the plate resistor even when the tube is removed, through the path provided through the leaky capacitor and through the grid resistor of the output stage to ground. Thus, if the capacitor C_1 is suspected of being shorted, connect the meter leads across R_L and remove the tube V_1 . If any current flows through the plate resistor, as shown by a voltage drop across it, there is leakage in the coupling capacitor. The alternative method is to disconnect the capacitor suspected at the grid side, as

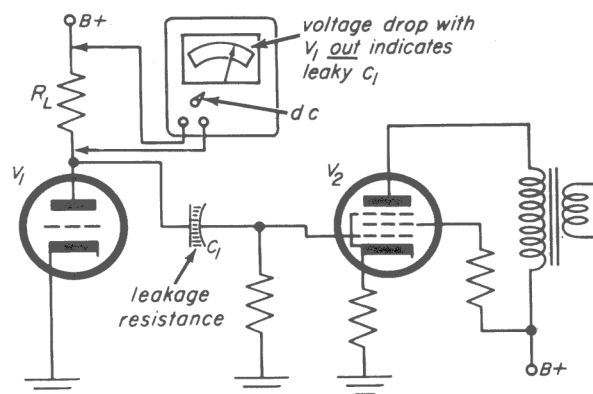


Fig. 38-5

shown in Fig. 38-6. The d-c voltmeter is then connected from the free end of the capacitor to the chassis. If the capacitor is leaky, its leakage resistance, the voltmeter resistance, and the plate resistance will form a voltage divider across the B+ supply. Since the voltmeter resistance is relatively high, a good portion of the total voltage will be developed across it. A sizeable deflection of the needle will be obtained to indicate the presence of leakage. It is necessary to disconnect the capacitor from the grid of the following tube, because the positive voltage on the grid may make the resistance from grid to ground very low and conceal the presence of the leakage voltage.

Because of the relatively low voltage at which such capacitors usually operate, shorted cathode bypass capacitors are not often encountered. However, the symptoms of such a defect are poor sound quality and distortion, as demonstrated in the experiment.

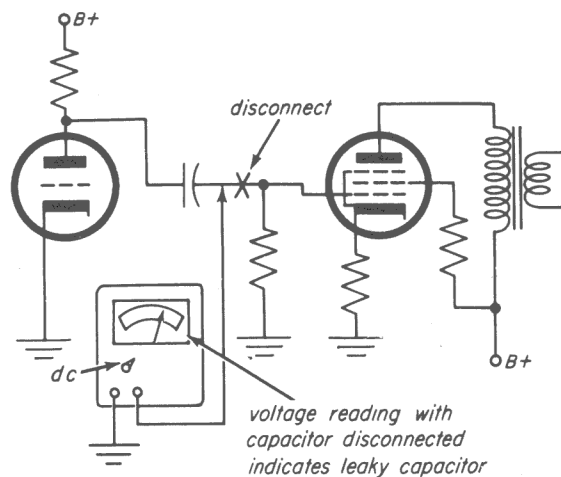


Fig. 38-6

EXPERIMENT 38-5

To perform further troubleshooting of the power-output stage.

Procedure.

Step 1. Connect a short jumper between pins 7 and 8 of the output tube to simulate a heater-to-cathode short.

Step 2. Operate the receiver and note the effect. What is heard in the loudspeaker? Is it affected by tuning? Is it affected by the volume control?

Step 3. Measure the a-c component (use output meter connection) of the voltage at the cathode (pin 8) of the output tube.

Record the voltage here:

volts a.c.

Why does a voltage exist at this point now even though the cathode is bypassed to ground with a large electrolytic capacitor.

Discussion. A heater to cathode short applies 60-cycle a-c voltage to the cathode, which, in effect, applies the signal between grid and cathode of the output tube. It is amplified and is very audible in the loudspeaker. The voltage exists at the cathode even though it is bypassed, because at 60 cycles even a capacitor as large as 25- μ f has several hundred ohms reactance. It is important to note that the volume control has no effect on the hum. This is because the hum signal originates in the receiver after the volume control. By listening carefully, it can be observed that the frequency of this hum is lower than the hum frequency caused by poor filtering, which is 120-cycle hum in this receiver.

EXPERIMENT 38-6

To study a precaution necessary when testing tubes for shorts with an ohmmeter.

Information. While troubleshooting a receiver, certain symptoms may lead you to suspect that a tube is developing a grid-to-cathode short when it heats up. It may occur to you that you can test for this condition by turning off the receiver and quickly putting the ohmmeter test prods across the grid and cathode terminals of the tube while it is still hot. It is important to note that proper polarity of the ohmmeter test prods must be observed in making such a test; otherwise, the test may lead to erroneous conclusions. The reasons for this are demonstrated in this experiment.

Procedure.

Step 1. Temporarily disconnect the lead from pin 5 of the output tube to the tone control.

Step 2. Turn on the receiver and allow the tubes to warm up.

Step 3. While allowing the tubes to become heated, connect the negative meter lead to the chassis (check to see that the black test lead is in the COMMON jack on meter and that the red test lead is in the POS jack on the meter). Set up the meter to measure resistance on the R x 10K scale.

Step 4. Turn off the receiver and touch the positive test prod to pin 5 of the output tube. Work quickly!

Record the resistance indicated by the meter:

ohms.

Step 5. Touch the positive test prod to the chassis, and the negative test prod to the grid (pin 5) of the output tube.

Record the resistance indicated on the meter:

ohms.

Do the readings you have recorded in Steps 4 and 5 indicate that your output tube has a grid to cathode short?

Step 6. Reconnect the lead from the grid of the output tube to the tone control.

Discussion. This experiment shows that an ohmmeter connected across the grid and cathode of a tube while the tube is still hot will give a very low resistance reading when the positive meter lead is connected to the grid, but will indicate an open circuit when the negative meter lead is connected to the grid. Real leakage due to a defect in the tube will indicate the same resistance, regardless of the polarity of the meter leads. The low resistance reading in one case is due to electron emission from the tube that is still hot (Fig. 38-7). This allows current flow from grid-to-cathode to occur when the positive meter lead is connected to the grid and is like an apparent short. Keeping this point in mind may save you from wasting a lot of time.

EXPERIMENT 38-7

To perform further troubleshooting of the power output stage.

Procedure.

Step 1. Turn on the receiver and allow the tubes to warm up.

Step 2. Connect the meter to measure the d-c voltage at the plate of the output tube.

Step 3. With a screwdriver, short the grid (pin 5) to the chassis while observing the d-c plate voltage on the meter. Is there any change in the plate voltage as the grid resistor is being shorted out? What would be indicated by such change?

Discussion. The simple steps outlined above are the basis of a gas or grid-emission test. As a troubleshooting technique, it has valuable applications in many television and other electronic circuits.

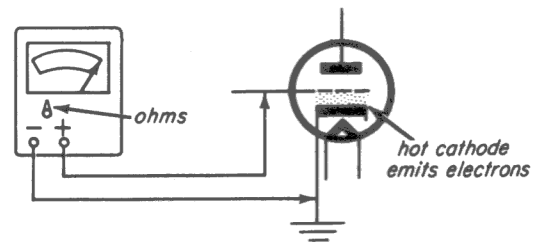


Fig. 38-7

Gas in the tube and grid emission occurs frequently in certain types of audio-power output tubes, often after they have been on 20 to 30 minutes. As a result, electrons may flow up through the grid resistor, as shown in Fig. 38-8, producing a bias voltage across the resistor of the polarity shown. This bias voltage is opposite in polarity to the voltage developed across the cathode resistor and thus reduces the total amount of bias. Although the total bias is still negative, distortion of the audio output is a result of the reduced bias. Of course, this condition could be checked by measuring the voltage drop across the grid resistor. Normally, no voltage drop should exist across this resistor. However, this voltage is small and may be difficult to measure. When the grid resistor is loaded down with the meter, the total grid resistance may be reduced enough so that this voltage becomes too small to measure. By making use of the following technique it can be indirectly determined whether or not there is a voltage across the grid resistor as a result of a defective output tube. Connect the meter to the plate of the output tube and set up the

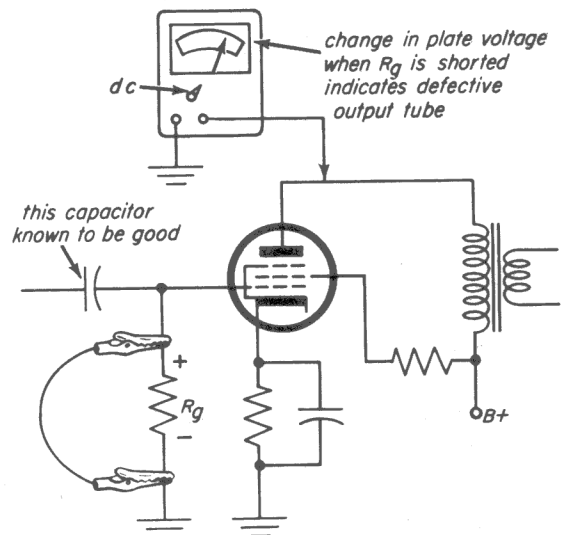


Fig. 38-8

meter to measure the d-c voltage at the plate of the output tube. Then with a short jumper, or screwdriver short out the grid resistor while observing the d-c plate voltage meter. There should be no change in bias. This could occur only if current were flowing through the grid resistor, an indication of a defective output tube. It is assumed that the possibility of a shorted coupling capacitor has already been eliminated by the methods described elsewhere in this lesson.

EXPERIMENT 38-8

To study a cause of motorboating in an audio amplifier.

Procedure.

Step 1. At the triangle section (20- μ f 300 volt) of the electrolytic capacitor, disconnect the lead from lug 3 of TS-C.

Step 2. At the semicircle section (40- μ f 300 volt) of the electrolytic capacitor, disconnect the red lead of the output transformer.

Step 3. Connect one lead of the 5,000-ohm 10-watt resistor to the triangle section of the electrolytic capacitor.

Step 4. Connect the red lead from the output transformer and the B+ lead from terminal strip TS-C together to the other lead of the 5,000-ohm resistor.

Step 5. Turn on the receiver and allow the tubes to warm up. What is heard in the loudspeaker?

Step 6. Restore all the connections to normal, and remove the 5,000-ohm resistor.

Discussion. The characteristic putt-putt sound heard is described as motorboating. When it occurs in audio amplifiers, it may sometimes be very difficult to locate. Its usual cause is an impedance that is common to the plate circuits of two stages, as simulated in this experiment by the 5,000-ohm resistor. The connection of this re-

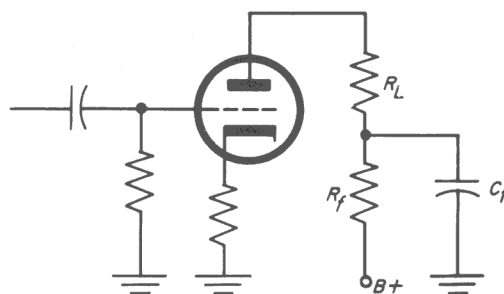


Fig. 38-9

sistor in the circuit is such that the signal currents of both the first audio amplifier stage and the output amplifier stage flow through it. The feedback is produced and fed from one stage to the other by this common resistor and results in this characteristic low-frequency oscillation.

In practice, this common impedance may be due to insufficient filtering, open electrolytic filter capacitors, or a filter capacitor that has developed a high internal impedance at one or more frequencies.

Sometimes, additional decoupling filter networks of the type shown in Fig. 38-9 are used to keep signal currents out of the power supply in order to prevent motorboating. In troubleshooting complaints of this type, such decoupling filter networks should be carefully checked. In addition, all the electrolytic filter capacitors of the power-supply itself should be checked.

EXPERIMENT 38-9

To observe normal indications for the first audio-amplifier stage.

Procedure.

Step 1. With power disconnected from the receiver, and using the appropriate ohm-meter scale, make the resistance measurements called for in Table G.

Step 2. Apply power to the receiver. Measure and record the d-c voltages called for in Table H.

Step 3. Plug in the signal generator and allow it to warm up. Check to see that the signal generator output cable is connected

TABLE G	
Measurement	Resistance (ohms)
Plate of first audio tube to chassis	
Control grid of first audio tube to chassis	
Cathode of first audio tube to chassis	

to the AF OUTPUT jack, and that the modulation switch is turned on. Connect the signal generator cable to the control grid of the first audio tube. With the output meter also connected to the control grid of the tube, adjust the AF OUT/INT MOD control to give one-half volt on the meter. More than one-half volt should not be used; otherwise the first audio tube will be overloaded. Then transfer the meter leads to the plate of the first audio stage and note the reading. Divide the second reading by the first reading to obtain the voltage gain of the stage.

TABLE H	
Measurement	Voltage (volts d.c.)
Plate of first audio tube	
Control grid of first audio tube	

Discussion. A schematic diagram of the first audio amplifier section of your receiver appears in Fig. 38-10. The proper resistance readings that should be obtained at the various points called for in Table G can be readily predicted from the circuit component values given on the schematic diagram. The voltage readings that should be obtained for this receiver are given in this diagram. Table I gives the range of d-c voltages that are likely to be encountered in a typical stage of this type:

TABLE I	
Measurement	Voltage (volts d.c.)
Plate voltage	75 to 150
Grid voltage	-0.5 to -1
Cathode voltage	0

The grid voltage listed in Table I is the *contact bias* obtained from the high-value grid resistor. The actual amount of voltage measured will depend on the value of this resistor, and the loading effect introduced by the meter resistance.

With the signal-generator output cable connected directly to the control grid of the first audio amplifier tube and the audio output control adjusted to give one-half volt, about 25 volts is obtained at the plate of the tube. Thus a gain of about 50 times by the first audio amplifier is indicated. This test is a valuable troubleshooting indication when the cause of weak output is being investigated.

EXPERIMENT 38-10

To make dynamic checks for the first audio stage.

Procedure.

Step 1. Plug in the receiver and allow the tubes to warm up.

Step 2. Tune the receiver off station, or remove the r-f amplifier tube so that the re-

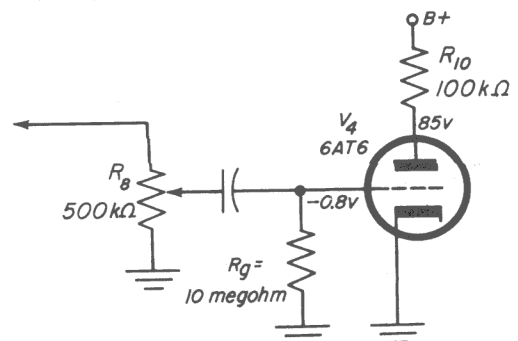


Fig. 38-10

ceiver is quiet. Turn the volume control to its maximum position.

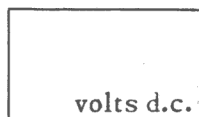
Step 3. Hold a small screwdriver so that your fingers touch the metal shaft of the screwdriver, and touch the tip to terminals 1, 2, and 3 of the volume control, in order. What is heard? Does this indicate that both the first audio stage and the output stage are operating?

Step 4. Using a relatively large capacitor (0.05 μ f or larger) inject 60-cycle filament voltage from any convenient filament connection on the chassis to the center tap of the volume control. What is heard? What is the advantage of this method over the "finger tests"?

Step 5. Turn on the signal generator and allow it to warm up. Check to see that the signal generator output cable is connected to the AF OUTPUT jack. Connect the cable to the center tap of the volume control and chassis. What is heard in the loudspeaker? What is the advantage of this test over the previous one?

Step 6. Disconnect the signal generator. Remove and quickly reinsert the 6BA6 i-f amplifier tube from its socket several times. What is heard in the loudspeaker? Now turn the volume control to its minimum position. Again remove and quickly reinsert the 6BA6 i-f amplifier tube several times. Are clicks still heard in the loudspeaker? Is the click test a reliable one at this point?

Step 7. Measure and record the d-c voltage drop across the 6AT6 plate load resistor:



What is established by the presence of a voltage drop across this resistor?

Discussion. The various methods of signal injection described in the experiment above all provide a means for rapidly checking operation of the entire audio section of the receiver. When you are troubleshooting

a dead receiver, you can use one or more of these checks to divide the receiver approximately in half, by isolating the defect location as being either before or after the volume control in the receiver. As your experiment should indicate, clicking an i-f tube to test the audio section is not too reliable. When the volume control is turned to minimum, no signal can pass from the i-f portion of the receiver to the audio portion. Yet clicking the i-f tube causes clicks in the loudspeaker. Thus it is wrong to assume that the presence of these clicks indicates that signal is capable of passing through the audio amplifier. The clicks are caused by surges in the common B+ line when the tube is replaced and starts to draw current. While the finger test is very quick and convenient, the amount of audible indication obtained in this way depends somewhat on the amount of electrostatic shielding between the primary and secondary windings of the power transformer. Thus varying results may be obtained with different receivers. Actual injection of 6.3-volts a-c across the volume control through a capacitor will give more consistent results. In both cases, however, the audio indication is a 60-cycle growl. Even very serious distortion will be masked by this growl. A sine-wave audio signal from a signal generator provides a clear tone that makes possible the detection of distortion.

The d-c voltage drop across the plate-load resistor of the first audio tube is valuable as an indication that current is flowing through the tube.

EXPERIMENT 38-11

To troubleshoot the first audio stage.

Procedure.

Step 1. Disconnect the filament voltage from the 6AT6 tube to simulate a defective tube.

Step 2. Measure and record the d-c voltages called for in Table J.

What does this voltage drop measurement tell about the plate current flowing in this

TABLE J

Measurement	Voltage (volts d.c.)
Plate voltage of 6AT6	
B+ supply voltage to 6AT6	
Voltage drop across 100 k-ohm resistor	

tube? How does this voltage drop compare with the difference between the B+ supply voltage and the plate voltage?

Step 3. Reconnect the filament voltage wiring.

Step 4. To simulate an open plate-load resistor, disconnect the 100 k-ohm resistor at the plate of the 6AT6. Measure and record the d-c voltages called for in Table K.

Step 5. Since it is possible that the zero voltage reading at the plate is due to a shorted tube, check by removing the tube. If the source of trouble is a short from the tube, the plate voltage should now return to normal.

Remove the 6AT6 tube, and measure and record the plate voltage of the 6AT6:

volts d.c.

Has the voltage returned to normal with the tube removed?

Step 6. Reconnect the plate-load resistor.

Step 7. To simulate a defective volume

TABLE K

Measurement	Voltage (volts d.c.)
Plate voltage of the 6AT6	
B+ supply voltage to 6AT6	

control, disconnect the ground of the volume control to the chassis. Operate the receiver and the volume control. What symptoms are heard from the loudspeaker?

Discussion. It is easy to locate a defective first audio amplifier tube when you measure the same voltage on both sides of the plate resistor (no voltage drop across this resistor). This indicates that there is no current flowing through this tube. Since the circuit connections of this tube are extremely simple (that is, the cathode is directly grounded and the grid is grounded through a 10-megohm resistor) this can be due only to a defective tube. An open plate-load resistor results in no plate voltage at the tube. Since there is supply voltage on the other side of the resistor, the resistor must be open. The method of checking for the possibility of a shorted tube has been described in Step 5 above.

The effect of an ungrounded volume control is to cause erratic control of the volume and considerable distortion. The volume is at or near maximum, and cannot be reduced, which indicates a defect in the volume-control circuit. You might think that no output at all would result from an open volume control, since this resistor is the detector load. However, there is enough leakage resistance across the tube socket and other parts of the chassis to complete the detector circuit. However, because the detector load resistance is so high, considerable distortion is produced.